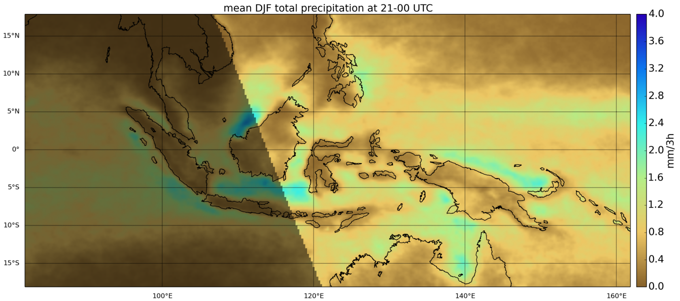
Representing coastal tropical convection using a stochastic modeling framework



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Large-scale atmosphere to rainfall relationship

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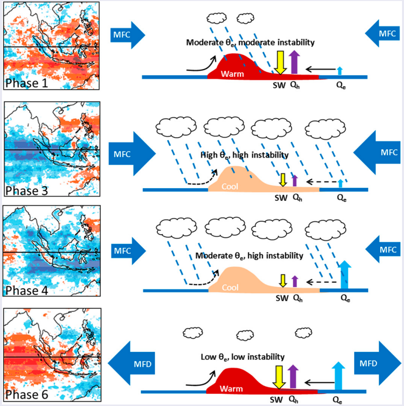
Large-scale ↔ meso-scale circulations by MJO phase



Birch et al. (JClim, 2016)

Large-scale atmosphere to rainfall relationship

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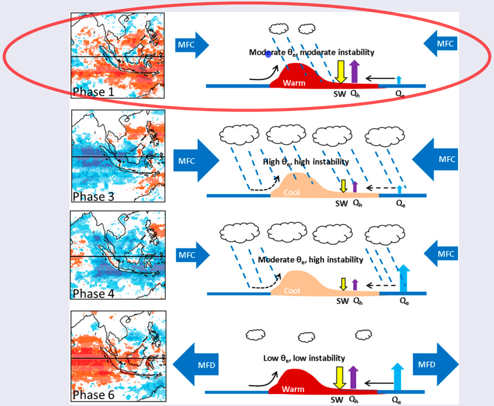

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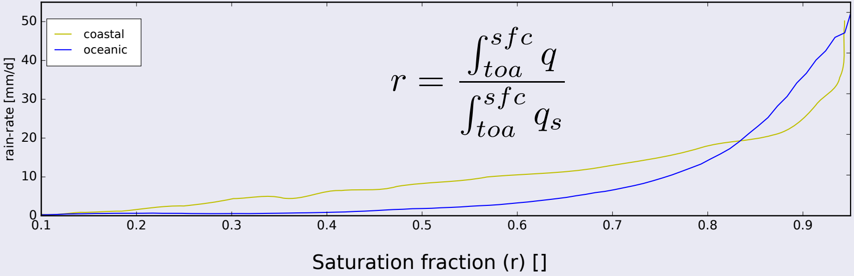
Large-scale atmosphere to rainfall relationship

Rainfall $\longleftrightarrow$ Humidity



$$r = \frac{\int_{toa}^{sfc} q}{\int_{toa}^{sfc} q_s}$$

Large-scale atmosphere to rainfall relationship

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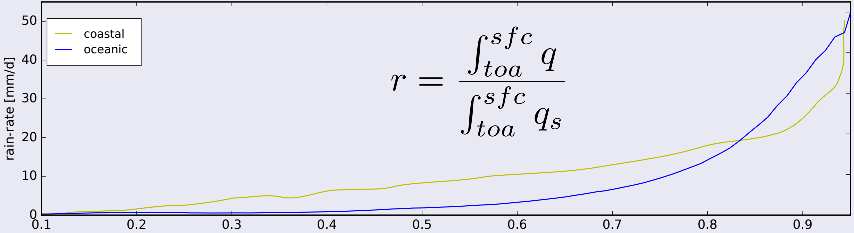

$$r = \frac{\int_{toa}^{sfc} q}{\int_{toa}^{sfc} q_s}$$

Saturation fraction (r) []

Rainfall is more likely to occure in drier conditions when coastal effects are present

How can convection that is mainly driven by coastal meso-scale circulations be represented in a parametrization framework?

Modification of the Stochastic-Multicloud-Model (SMCM)

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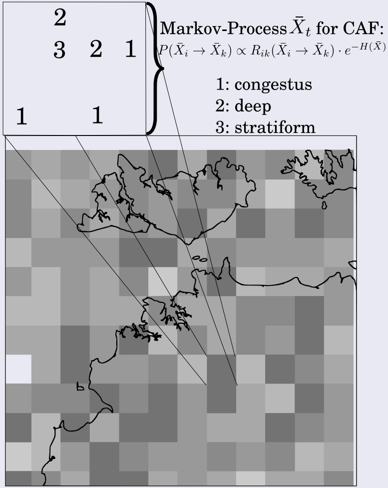
Particle interacting system to describe cloud area fraction



With:

- $\rho(\bar{X}_i \to \bar{X}_k)$ atmospheric conditions
- $H(\bar{X})$ neighborhood

Calculate birth, death and transitions rates R_{ik} between the cloud types.

Added expression for thermal-heating contrast

original version:
$$R_{12} = \Gamma(C) \cdot (1 - \Gamma(D)) \cdot \frac{1}{\tau_{12}}$$
modified version:
$$R^*_{12} = \tilde{\Gamma}(\Delta T)) \cdot \Gamma(\tilde{C}) \cdot (1 - \Gamma(\tilde{D})) \cdot \frac{1}{\tau_{12}}$$

With:
$$\Gamma(x) = \max(1 - e^{-x}, 0)$$
$$\tilde{\Gamma}(\Delta T) = \left(\arctan\left(\Delta T + \frac{\pi}{2}\right) + \frac{\pi}{2}\right) \cdot \frac{6}{5 \cdot \pi}$$
$$\tilde{C} = \max(C + \gamma \cdot \Delta T, 0) \quad \tilde{D} = \max(D + \gamma \cdot \Delta T, 0)$$

Experimental setup

original version:

$$R_{12} = \Gamma(C) \cdot (1 - \Gamma(D)) \cdot \frac{1}{\tau_{12}}$$

modified version:

$$R^*_{12} = \tilde{\Gamma}(\Delta T)) \cdot \Gamma(\tilde{C}) \cdot (1 - \Gamma(\tilde{D})) \cdot \frac{1}{\tau_{12}}$$

With:

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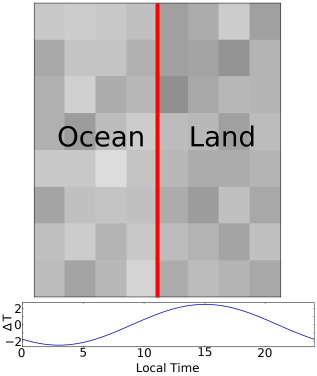
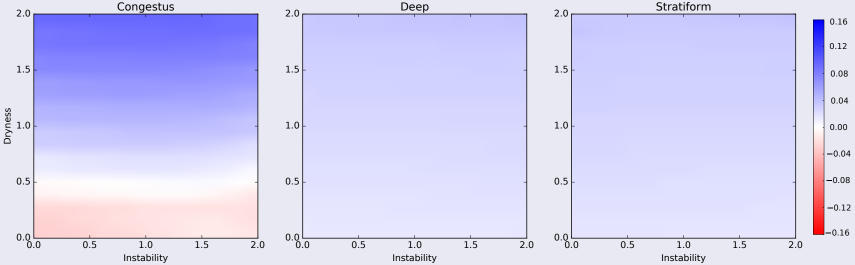
$$\tilde{C} = \max(C + \gamma \cdot \Delta T, 0) \quad \tilde{D} = \max(D + \gamma \cdot \Delta T, 0)$$



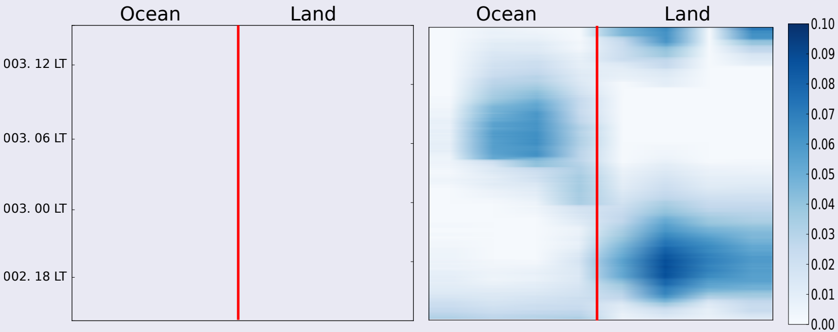
Sensitivity tests:

Cloud area fraction with instability and dryness (modified - original)



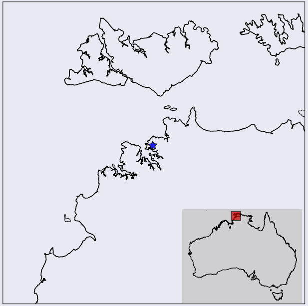
Spatio-temporal organization:

Diurnal cycle in a Hovmöller diagram



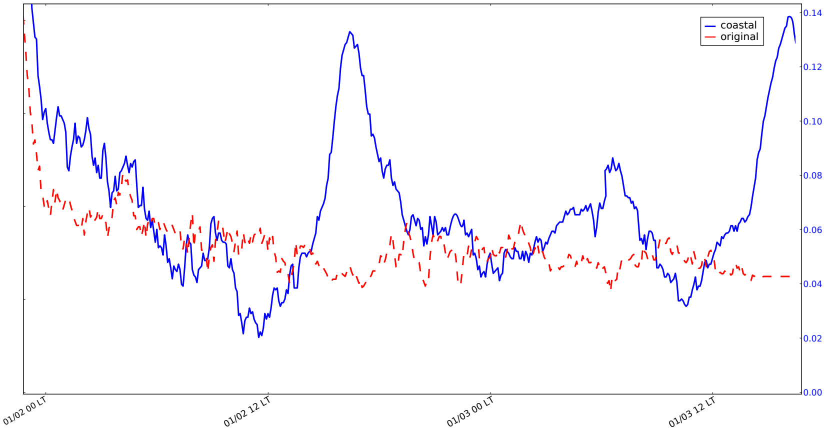
Real world example:

drive model with obs. data from Darwin



- period: Jan 1st 1998 - Jan 4th 1998
- data : ERA-Interim (6 hours, 0.75°):
  - $D = 2 \cdot (1 - r)$
  - $C = \frac{1\mathrm{h}}{10\mathrm{hPa}} \cdot \omega_{600\mathrm{hPa}}$
  - $\Delta T = \overline{T}_{\mathrm{land}} - \overline{T}_{\mathrm{sea}}$

Results:


coastal
original
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
01/02 00 LT
01/02 12 LT
01/03 00 LT
01/03 12 LT

Conclusions

simple characterization of coastal meso-scale circulations is more engineering then science but

- it improves the spatio-temporal organization of convection
- it reproduces the large-scale atmosphere to deep convection relationship near coasts

$\longrightarrow$ the SMCM can provide a framework to parameterize many other meso-scale processes